PATENT ABSTRACTS OF JAPAN

(11)Publication number : **09-271919**

(43)Date of publication of application : **21.10.1997**

(51)Int.Cl.
B22D 17/00
B22D 21/04
C22C 1/02
C22C 1/02
C22C 23/02

(21)Application number : **08-082829**

(22)Date of filing : **04.04.1996**

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(54) **PRODUCTION OF HEAT RESISTANT MAGNESIUM ALLOY MEMBER, MAGNESIUM ALLOY USED TO IT AND FORMED MEMBER MADE OF MAGNESIUM ALLOY**

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain a formed product excellent in room temp. and high temp. strength by using a specific composition of magnesium alloy and executing injection forming or semimelting forming.

SOLUTION: This alloy has composition composed, by wt.%, of 2-10% aluminum, 1.0-10% calcium and the balance magnesium with inevitable impurities. Further, ≤2% at least one kind of element selected from the group of zinc, manganese, zirconium and silicon and/or ≤4% rare earth metals are added, at need. This alloy is formed into metallic grain or pellet and the injection forming is executed at the liquidus temp. or lower of the alloy or the semimelting forming is executed at the liquidus temp. or lower of mixture of the solid phase and the liquid phase. This formed product shows 200MPa 473K tensile strength and 14% elongation percentage, and further, shows 0.1244% strain at the initial stage, and ≃0%h min. creep velocity in the condition of 50MPa test load in the tensile creep test at 125°C.

LEGAL STATUS

[Date of request for examination]	28.11.2002
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3522963
[Date of registration]	20.02.2004
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

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2. Texts in the figures are not translated and shown as it is.

Translated: 23:51:30 JST 02/20/2006
Dictionary: Last updated 01/27/2006 / Priority: 1. Chemistry / 2. Mechanical engineering / 3. Architecture/Civil engineering

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FULL CONTENTS

[Claim(s)]
[Claim 1] The manufacture method of the heat-resistant Magnesium alloy member characterized by carrying out injection molding of the Magnesium alloy with which 2 to 10 weight % of aluminiums and 1.0 to 10 weight % of calcium are contained, and the remainder consists of magnesium and an inescapable impurity by abbreviation liquidus temperature or less than it.
[Claim 2] The manufacture method of a heat-resistant Magnesium alloy member according to claim 1 that the shaping method is the half-melt molding method for performing injection molding at the temperature below the liquidus in which solid phase and the liquid phase are intermingled.
[Claim 3] The manufacture method of a heat-resistant Magnesium alloy according to claim 2 that the rate of solid phase at the time of a semi molten state is 25% or less when performing half-melt molding.
[Claim 4] The manufacture method of the heat-resistant Magnesium alloy according to claim 1 to 3 which contains 2 or less weight % and/or 4 or less weight % of **** elements for at least one sort of elements with which the Magnesium alloy was chosen from the group which consists of zinc, manganese, zirconium, and silicon further.
[Claim 5] The manufacture method of a heat-resistant Magnesium alloy according to claim 1 to 4 that a Magnesium alloy is a metal grain or a pellet form.
[Claim 6] The object for half-melt molding or the Magnesium alloy for injection molding with which 2 to 10 weight % of aluminiums and 1.0 to 10 weight % of calcium are contained, and the remainder consists of magnesium and an inescapable impurity.
[Claim 7] The object for half-melt molding according to claim 6 or the Magnesium alloy for injection molding which contains 2 or less weight % and/or 4 or less weight % of **** elements for at least one

sort of elements with which the Magnesium alloy was chosen from the group which consists of zinc, manganese, zirconium, and silicon further.
[Claim 8] The object for half-melt molding according to claim 6 or 7 or the Magnesium alloy for injection molding whose Magnesium alloy is a metal grain or a pellet form.
[Claim 9] The Magnesium alloy shaping member manufactured by the method according to claim 1 to 5.

[Detailed Description of the Invention]
[0001]
[Field of the Invention] The Magnesium alloy which uses this invention for the manufacture method of a Magnesium alloy member and it excellent in a room temperature and high temperature strength, And it is related with injection molding of the Magnesium alloy which has hardness sufficient also at the elevated temperature up to about 473 degrees K currently demanded in weight savings, such as automobile-engine components, in more detail about a Magnesium alloy shaping member.
[0002]
[Description of the Prior Art] From a rise of the consciousness of earth environment maintenance, the request of the improvement in fuel consumption of an automobile becomes strong, and development of the lightweight ingredient for automobiles has come to be called for strongly in recent years. Also in the metallic material put in practical use now, a Magnesium alloy is lower density most and is strongly expected as future lighter weight materials for automobiles. The Magnesium alloy present most generally used is a Mg-aluminum-Zn-Mn system alloy (for example, AZ91 alloy = Mg-9aluminum-1Zn-0.2Mn), and this alloy has been first examined in an automobile weight saving. However, the Mg-aluminum-Ca-Mn system alloy (JP,H6-25790,A) is newly proposed noting that this seed alloy does not fit the application as which hardness falls at about 393 degrees K or more, and a heat-resisting property is required also in automobile-engine components. If the ratio of Ca/aluminum is made or more into 0.7, the form of organization of the deposit crystallized in a Magnesium alloy will change, and the Mg-Ca compound supposes that the high-temperature-strength characteristics which crystallized and were excellent come to be shown especially here.
[0003]
[Problem to be solved by the invention] However, in the dies casting conventionally used widely, it was easy to generate hot tearing, and if newly proposed AC alloy has a high molten metal temperature, it has left the technical problem of being easy to generate the seizure to a metal pattern. This invention sets it as the main object to offer the suitable shaping method replaced with the dies casting of a Magnesium alloy suitable for charges of engine components lumber, such as an automobile by which both a heat-resisting property and room temperature hardness are demanded, in view of the technical problem which such a conventional technique has. Moreover, other objects of

this invention are to offer the Magnesium alloy member which is excellent in both the heat-resisting property manufactured by the Magnesium alloy presentation and the above-mentioned shaping method of being suitable for the above-mentioned shaping method, and room temperature hardness.

[0004]

[Means for solving problem] If they carry out at the temperature below a low-temperature liquidus from pressure die casting even if it adopts the injection-molding method for excelling in high-volume production capability, as a result of this invention persons' repeating analyses variously, in order to solve the above-mentioned technical problem Even if it sets up a Magnesium alloy presentation regardless of the ratio of above-mentioned Ca/aluminum While the shaping member equipped with the heat-resisting property which matches when manufactured by the dies casting of AC alloy which set the ratio of above-mentioned Ca/aluminum or more to 0.7, and room temperature hardness was obtained, it found out that the inclination of above-mentioned hot-tearing metallurgy type seizure reduced substantially. Therefore, this invention contains 2 to 10 weight % of aluminiums, and 1.0 to 10 weight % of calcium. The manufacture method of the heat-resistant Magnesium alloy member characterized by carrying out injection molding of the Magnesium alloy with which the remainder consists of magnesium and an inescapable impurity by an abbreviation liquidus or less than it is offered.

[0005] In order to inject dies casting at an abbreviation liquidus or the temperature not more than it with injection molding of this invention to generally injecting in a metal pattern at the molten metal temperature of 30-50 degrees C on melting temperature, injection temperature at least will fall by 30-50 degrees C or more.

[0006] It is desirable to adopt the half-melt molding (following only half-melt molding) which performs injection molding in the condition that the solid phase and the liquid phase below a liquidus are intermingled unlike injection molding (only henceforth injection molding) especially fabricated at the injection temperature of an abbreviation liquidus. First of all, since it is the coagulation from half-melting and a coagulation stress becomes small, it seems by using this method that the development of hot tearing can be controlled.

[0007] These effects are remarkable in 25% or less of the rate of solid phase in a half-melt molding method in particular. Therefore, when performing this half-melt molding, it is desirable that the rate of solid phase at the time of a semi molten state is 25% or less. It seems that a seizure and coagulation stress is also advantageous so that the rate of solid phase is generally high, but by this invention method, since flowability will fall if the rate of solid phase is high, lowering of restoration nature and the development of a cold shut take place easily, and it becomes difficult to obtain a healthy shaping member. Moreover, it is in the inclination whose hardness of a shaping member also improves in 25% or less of the rate of solid phase.

[0008] In this invention, the effect which is not acquired can be attained at pressure die casting by applying the describing [above] half melt molding method and an injection-molding method to the following heat-resistant Magnesium alloys instead of general-purpose AZ alloy. It is considered to be

the result from which the crystalline structure which was not obtained by dies casting by both organic binding was obtained that the knowledge of the effect by the combination of such an alloy and a molding method was not carried out conventionally. Generally, with a Magnesium alloy, it dissolves with magnesium and age-hardening nature is shown, and in order to raise the mechanical property of an alloy, 2 to 10 weight % of aluminiums are added. It is because less than 2 weight % is not enough as the addition effect, and the elongation of an alloy will fall with growth in an addition while the addition effect is saturated if 10 weight % of another side is crossed. By this invention method, it is applied to the thing which makes 1.0 to 10 weight % of calcium contain further. It is for addition of calcium reinforcing the high temperature strength in the inclination to fall, with addition of the aluminium to magnesium. It is because the addition effect is inadequate, and the addition effect will be saturated with less than 1.0 weight % if 10 weight % of another side is crossed.
[0009] The above-mentioned Magnesium alloy may contain 2 or less weight % and/or 4 or less weight % of **** elements (for example, yttrium, neodium, lanthanum, cerium, a misch metal) for at least one sort of elements chosen from the group which consists of zinc, manganese, zirconium, and silicon further. These checked the same thing, also when the hardness or high temperature strength of the above-mentioned Magnesium alloy is effectively raised below in the maximum and this invention method was applied.
[0010] In carrying out injection molding of the above-mentioned Magnesium alloy by this invention method, it is necessary to consider it as a metal grain or a pellet form. Therefore, although the metal grain or pellet more than the diameter of an average of 3mm is used, if the cut etc. gives processing distortion, alloy composition after shaping will be made detailed and it will be useful for the improvement in hardness. As the processing method, cutting is advantageous in cost.
[0011]
[Mode for carrying out the invention] The entire configuration of the making machine 1 used for the half-melt molding method and injection-molding method which start this invention at drawing 1 is shown. By the shaping method of this invention, the Magnesium alloy metal grain produced by methods, such as a mechanical cut, by the hopper 8 in drawing or the raw material 3 of a pellet (3mm or more of diameters) is thrown in. A raw material 3 is supplied in a cylinder 4 through the pass gate 7 of the argon atmosphere from a hopper 8. Within this cylinder 4, while a raw material 3 is ahead sent on a screw 2, it is heated. 10 shows this heating zone. Cooking temperature will be in the semi molten state in which solid phase and the liquid phase were intermingled as it was illustrated at the temperature below a liquidus, although the Magnesium alloy raw material 3 would be in the molten state in an abbreviation liquidus. Moreover, as for the Magnesium alloy in a semi molten state, the shearing force divides solid phase finely like a graphic display by revolution churning of a screw. Here, when a screw 2 is ahead extruded at back high-speed catapult guard 5, the high-speed injection of the molten metal to which beating of the solid phase was carried out will be finely carried out from a nozzle 9 like a graphic display by a semi molten state, and it will fill up in a metal pattern 6. Here, application-of-pressure maintenance of the inside of a metal pattern is carried out to

coagulation, an after [coagulation] type is opened, and shaping products are taken out.
[0012] The iron crucible was installed in the example 1-15 and the comparative example low frequency furnace, and the alloy of the component of an example and a comparative example was ingoted, making SF6 gas 1% (** being dry air) flow on the molten metal surface. These alloys were cast to tabular, the pellet of the diameter of 3-5mm was manufactured with milling, and half-melt molding and injection molding were performed using the above-mentioned making machine by making these into a raw material. Using the machine of 450t of mold clamp force, an injection speed is about 700kg/cm2 in 50 m/s and injection pressure in a metal pattern gate part, and, as for both half-melt molding and injection molding, the condition set the temperature of the alloy of a nozzle part as each temperature of Table 1. Setting the temperature of this alloy as right above [fusing point] in the case of injection molding, others presupposed that it is the same as a half-melt molding method. In the above process condition, the test piece for tensile test (JIS No. 4 specimen) was created. Moreover, the frequency of hot tearing at the time of shaping and the seizure to a metal pattern was observed. The number of shaping was 150-500 pieces. Moreover, the check same at the hot chamber dies casting of 50t of mold clamp force was carried out. Each molten metal temperature of the conditions at this time is 1.5m [in the die temperature of 200 degrees C, injection pressure 160 kgf/cm2, and plunger velocity //second], and metal pattern time (DT) 2 to 3 seconds at 650 degrees C. In addition, the conditions of the tension test measured breaking strength and elongation after fracture with the Instron tensile testing machine at 10mm a part for /and measurement temperature of 25 degrees C in crosshead velocity, and 200 degrees C.
[0013] Although various molding methods, and the hardness and moldability for every alloy are shown in Table 1, even if it applies the semi-melting injection molding method of this invention with an alloy equivalent to AZ 91D from a comparative example 4-6 as compared with dies casting, ****** etc. is improved a little, but if it sees on a product level, a big difference will not be accepted on a material property. Moreover, it is printed also in dies casting and problems, such as hot tearing, are not generated. That is, it is that Merritt on a process, like not needing a melting furnace and there is little energy consumption is only enjoyable. On the other hand, from a comparative example 1-2 and an example 1-15, with the Magnesium alloy containing Ca, when this invention method is applied, in the existence and seizure frequency of a development of hot tearing, not only the effect of a betterment of a material property is also large, but has a big difference. That is, by this invention method, it turns out that hot tearing which is a trouble in dies casting shaping, and seizure are solvable by adopting a half-melt molding method and an injection-molding method.
[Table 1]

	Al (重量%)	Ca (重量%)	Mn (重量%)	その他 (重量%)	298K 引張強度 (MPa)	298K 伸び%	473K 引張強度 (MPa)	473K 伸び%	焼付き頻度	熱間割れ	成形法	溶湯温度
実施例1	3.0	3.0	0.2	--	260	8	200	14	0/175	なし	半溶融	580℃
実施例2	3.0	1.0	0.2	--	220	8	165	18	0/150	なし	半溶融	580℃
実施例3	3.0	5.0	0.2	--	255	6	220	10	0/170	なし	射出成形	600℃
実施例4	4.0	5.0	0.2	--	280	7	230	10	0/175	なし	射出成形	600℃
実施例5	4.0	1.0	0.2	Mm1.0	240	8	200	13	0/162	なし	半溶融	580℃
実施例6	5.0	1.0	0.2	Mm2.0	280	6	220	10	0/175	なし	半溶融	560℃
実施例7	5.0	7.0	0.2	--	260	5	240	8	1/163	なし	半溶融	560℃
実施例8	6.0	1.0	0.2	--	270	8	180	12	0/183	なし	射出成形	600℃
実施例9	6.0	5.0	0.2	Zn0.7	280	7	220	12	0/162	なし	半溶融	550℃
実施例10	9.0	1.0	0.2	Zn0.7	280	8	180	15	0/200	なし	半溶融	550℃
実施例11	9.0	7.0	0.2	--	300	3	200	6	2/224	なし	半溶融	550℃
実施例12	6.0	7.0	0.2	--	300	6	240	8	1/253	なし	半溶融	580℃
実施例13	6.0	3.0	--	Zr0.5	280	7	200	10	0/158	なし	射出成形	600℃
実施例14	6.0	3.0	0.2	Si1.0	270	6	200	10	0/237	なし	半溶融	600℃
実施例15	6.0	1.5	0.2	Mm1.5	290	8	190	14	0/270	なし	半溶融	580℃
比較例1	3.0	3.0	0.2	--	250	4	180	8	12/201	スプール部	ダイカスト	650℃
比較例2	6.0	3.0	0.2	--	260	3	130	7	13/325	スプール部	ダイカスト	650℃
比較例3	3.0	3.0	0.2	--	120	3	100	10	-	-	金型重力鋳造	680℃
比較例4	9.0	-	0.2	Zn0.8	270	5	115	19	0/180	なし	ダイカスト	650℃
比較例5	9.0	-	0.2	Zn0.8	270	7	120	20	0/175	なし	半溶融	550℃
比較例6	9.0	-	0.2	Zn0.8	180	6	90	20	-	-	金型重力鋳造	680℃
比較例7	4.0	-	0.2	Si1.0	220	8	145	12	0/183	なし	射出成形	600℃

[0014] If Table 2 fabricates the Magnesium alloy of an example by this invention method, excelling not only in high temperature strength but in the Kleave characteristics (based on the creep-under-tensile-force test method based on JIS Z 2271) is shown. Although AS41 of a comparative example 8 is the standardized heat-resistant alloy, it is inferior to the Magnesium alloy of an example 1 including AZ 91D of a comparative example 5. This is one of the Reasons a Magnesium alloy was not conventionally applied to the engine components for automobiles etc.

[Table 2]

合金名	試験温度	試験荷重30MPa 初期歪み%	試験荷重30MPa 最小クリープ速度%/h	試験荷重50MPa 初期歪み%	試験荷重50MPa 最小クリープ速度%/h
実施例1	125℃	0.0683	≅0	0.1244	≅0
AC33	150℃	0.0707	9.2×10^{-5}	0.1293	1.9×10^{-4}
比較例5	125℃	0.0780	1.9×10^{-3}	0.1268	7.6×10^{-3}
AZ91D	150℃	0.0780	6.3×10^{-3}	0.1537	8.2×10^{-2}
比較例8	125℃	0.0735	2.3×10^{-4}	0.1255	9.3×10^{-4}
AS41	150℃	0.0752	7.4×10^{-4}	0.1355	5.2×10^{-3}

[0015] Table 3 shows the effect of the rate of solid phase in a half-melt molding method, and the effect of the mean particle diameter of the organization of a shaping member. The rate of solid phase in a half-melt molding method has so small that it is low the mean particle diameter of the organization of a shaping member, and a density becomes high, namely, it turns out that hardness improves.

[Table 3]

	Ａｌ (重量%)	Ｃａ (重量%)	Ｍｎ (重量%)	固相率 (%)	密度 (g/cm^3)
実施例１	3	3	0.2	15	1.74
比較例９	3	3	0.2	26	1.67
比較例１０	3	3	0.2	30	1.66

[0016]

[Effect of the Invention] By the above description, according to this invention, a Mg-aluminum-Ca system heat resistance Magnesium alloy at an abbreviation liquidus or the temperature not more than it so that clearly half-melt molding or by carrying out injection molding Equivalent to a conventional method or the ordinary temperature beyond it, high temperature strength, and elongation can be held solving the technical problem of the hot-tearing metallurgy type seizure in the conventional pressure die casting. Therefore, manufacture with the Magnesium alloy of engine components, such as an automobile by which a light weight and a heat-resisting property are demanded, was enabled.

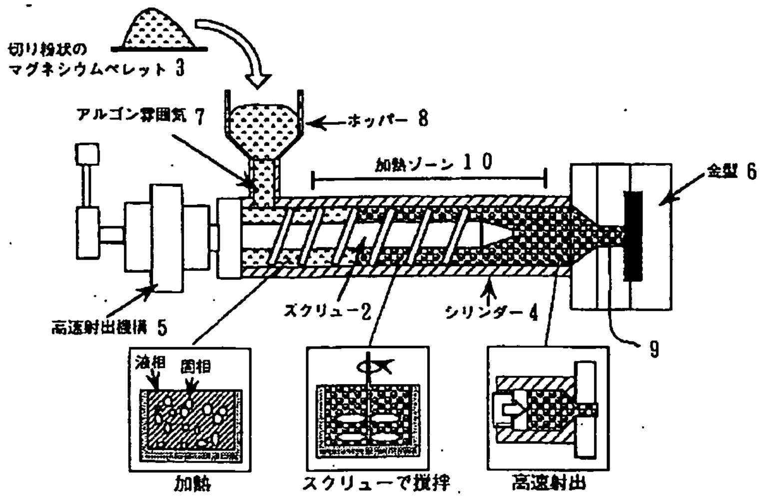
[Brief Description of the Drawings]

[Drawing 1] The outline figure showing the architecture of the making machine used for the half-melt molding method and injection-molding method concerning this invention.

[Explanations of letters or numerals]

1 -- Injection molding machine
2 -- Screw
3 -- Raw material pellet
4 -- Cylinder
5 -- High-speed catapult style
6 -- Metal pattern
7 -- Ingredient ****** to a cylinder
8 -- Hopper
9 -- Nozzle
I0 -- Heating zone

[Drawing 1]



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